B. RANGE CAPABILITIES ASSESSMENT

1. Mission Capabilities - The primary mission of the WFF Launch Range is to provide a safe and efficient site for NASA sounding rocket operations and to provide an east coast base for launching the NASA Scout rocket booster, an expendable launch vehicle used primarily to place small spacecraft into low earth-orbit. **Figure 6**[3] shows the allowable launch corridors for the Scout vehicle. Facilities on Wallops Island are used, as required, to support other NASA science and research programs, which may involve the use of small meteorological rockets or balloons to carry instruments to desired altitudes. In addition to support of NASA programs, the Launch Range is utilized for rocket and non-rocket programs of other U.S. Government agencies, where such use does not impact on the NASA sponsored activities. Typical other-agency programs supported include: VANDAL, a high speed target missile, for the Naval Air Test Center; sounding rockets for the Air Force Geophysics Laboratory; and full scale aircraft development programs for the Naval Air Test Center.[1]

2. Instrumentation Capabilities - Tracking and data acquisition activities at Wallops are covered by three functional areas: radar, telemetry and data systems, including communications and optics. These activities support the full range of sounding rocket, balloon and aeronautical research and development and scientific experimentation. Similar capabilities can be configured to support mobile operations worldwide. In addition, WFF has a satellite tracking facility as an integral part of the station telemetry capability.

a. Radar Systems[5] - The WFF radar system capabilities are shown in **Table 3**[5].

(1) AN/FPQ-6 - The AN/FPQ-6 is a C-band, monopulse tracking radar designed and built for precision long-range tracking. It is frequently referred to as a Missile Precision Instrumentation Radar (MIPIR).

At WFF, this radar is used primarily to provide launch vehicles position and velocity data in real time. It is capable of providing continuous, accurate spherical-coordinate information on cooperative targets out to a range of 37,000 miles.

During operation, the radar antenna will automatically track (skin or transponder) a launch vehicle or other airborne targets with a minimum of tracking jitter or bias. The radar is located on Wallops Mainland.

(2) AN/FPS-16 - One of two AN/FPS-16 radars at WFF is located on Wallops Island and is used primarily to provide rocket, balloon and satellite position data. It is a high precision, C-band, monopulse tracking radar and is capable of providing continuous, accurate spherical-coordinate information on targets out to a range of 37,000 statute miles. It will skin or transponder track and automatically follow a space or airborne target.

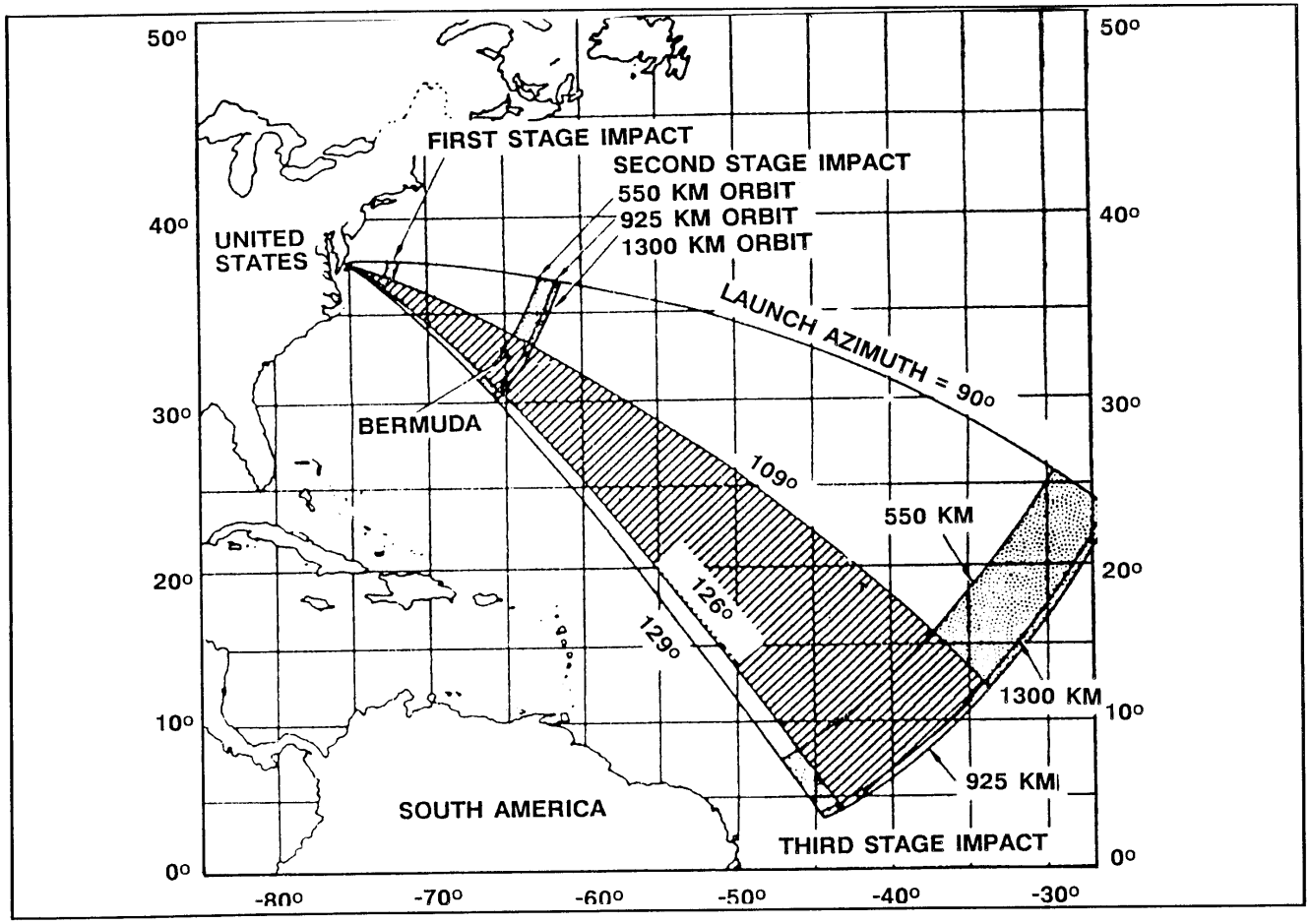

FIGURE 6. WFF ALLOWABLE LAUNCH CORRIDORS

TABLE 3. RADAR SYSTEM CAPABILITIES

RADAR	WAVE LENGTH BAND	PEAK POWER OUTPUT (WATTS)	PULSE RATE FREQUENCY (PPS)	BEAM WIDTH	ANTENNA DIAMETER (METERS)	ANTENNA GAIN (DB)	MAX RANGE (KM)	1-M^2 SKIN TRACK (KM)	RANGE PRECISION (METERS)	ANGLE PRECISION (MIL RMS)	SLEWING RATE (DEG/SEC) AZ EL
ASRF	UHF S	8M 5M	320-960 160,320,640,960	2.9 0.39	18.29 18.29	36 52.8	N/A 480K	1480 2200	N/A ±5	±2.0 ±1.0	8 8 15 15
AN/MPS-19	S	325K	160,320,640,1280	3.0	2.44	33	925	100	±10KMS	±1.0	60 60
AN/ASR-7	S	425K	713,1200,OTHERS AVAILABLE	1.5(AZ) CSC(EL)	5.33X 2.74	34	110	75 AIRCRAFT	±1%	N/A	N/A N/A
VERLORT	S	250K	410,512,585	2.53	3.05	37	4200	110	±25	±0.5	50 50
AN/FPQ-6	C	3M	160,640,OTHERS AVAILABLE	0.39	8.84	51	60K	1300	±3RMS	±0.05	28 28
AN/FPS-16 (ISLAND)	C	1M	160,640,OTHERS AVAILABLE	1.23	3.66	43	60K	350	±3RMS	±0.1	45 28
AN/FPS-16V AIRPORT RADAR LASER	 C INFRA	 1M 2.5M	 160,640,1024 40	 0.71 0.11	 4.88 0.18	 46 N/A	 60K 40	 435 N/A	 +3.0 ±0.5	 +0.1 ±0.1	 45 25 N/A N/A
RIR-778C (MOBILE)	C	1M	160,320,640	1.5(ACQ) 3.0(TRK)	2.38	38	3745	220	0.87204	0.2441	40 40
MARINERS #1 PATHFIND	X	40K	1000,4000	9.6@3db (H)	3.67X 0.15	30	175	28 SHIPS	N/A	N/A	N/A N/A
AN/APS-80BV	X	200K	400	2.4(H) 3.6(V)	1.18X0.81	35	155	N/A	N/A	N/A	N/A N/A
AN/APS-128E	X	100K	267,400,1200,1600	2.4(AZ) 9.0(V)	1.06X 0.305	31	125	N/A	±1% MAX RANGE	N/A	N/A N/A
RIR-778Ka	Ka	135K	320,640,1280	0.5(NOM)	2.38	54	468	80	0.4360	0.2441	40 40

(3) RIR-778C - There are three Range Instrumentation Radar (RIR) 778C radar systems at WFF. All are mobile C-Band precision computer based RF and optical tracking systems designed and built to obtain continuous and highly accurate positional data of various airborne targets for flight test programs. The RIR-778C is a mobile unit capable of conducting world wide missions. The system is capable of providing continuous, accurate, spherical-coordinate information on targets out to ranges of 2340 miles. It is capable of both skin and transponder tracking. The system will provide and record trajectory data in real time for future evaluation.

(4) AN/MPS-19 - WFF has one permanently installed AN/MPS-19 radar located on top of the Island Control Center on Wallops Island. This modified, narrow pulse, S-band tracking radar is used primarily for early acquisition of rockets and for weather balloon tracking. The AN/MPS-19 radar system is capable of acquiring and providing continuous automatic tracking of skin or transpond targets. A radar transponder is necessary to obtain maximum tracking range. As an early acquisition radar, the AN/MPS-19 provides azimuth and elevation data on the target being tracked to other WFF radars to aid them in acquiring the target.

(5) Mariners Pathfinder - The Mariners Pathfinder is an X-band search radar, Model 1605, used primarily to detect shipping that might be endangered by rocket firing at WFF. A movable range mark permits accurate ranging to any point 0.25 to 20 miles with an accuracy of 1%. Channel markers and buoys can be seen on fairly rough waters up to 2.8 miles and sometimes as far as 6.2 miles. This radar is located on Wallops Island.

(6) AN/APS-80B(V) Airborne Search Radar System -This radar was designed to perform range surveillance and is installed on one Lockheed Orion NP-3A aircraft (other aircraft are also used for airborne surveillance) stationed at WFF. It is used to locate ships or aircraft on the WFF test range. It can provide surveillance through a continuous 210 degrees in azimuth of a 45 degree sector scan. During ideal clear weather conditions, maximum range of the radar is 96 miles at the maximum altitude of 30,000 feet.

(7) AN/APS-128(E) Airborne Search Radar System -This radar is a high-powered airborne surveillance radar system designed for detection and surveillance of both airborne and surface seaborne targets. It is primarily used to locate ships that are operating on the WFF test range. The radar antenna is mounted in the belly of a Skyvan aircraft and scans 360 degrees as it searches for radar targets. During ideal clear weather conditions, maximum range of the radar is 230 miles. This set can be used as high as 16,000 feet.[5] See **Figure 7**[5] for a typical radar system block diagram.

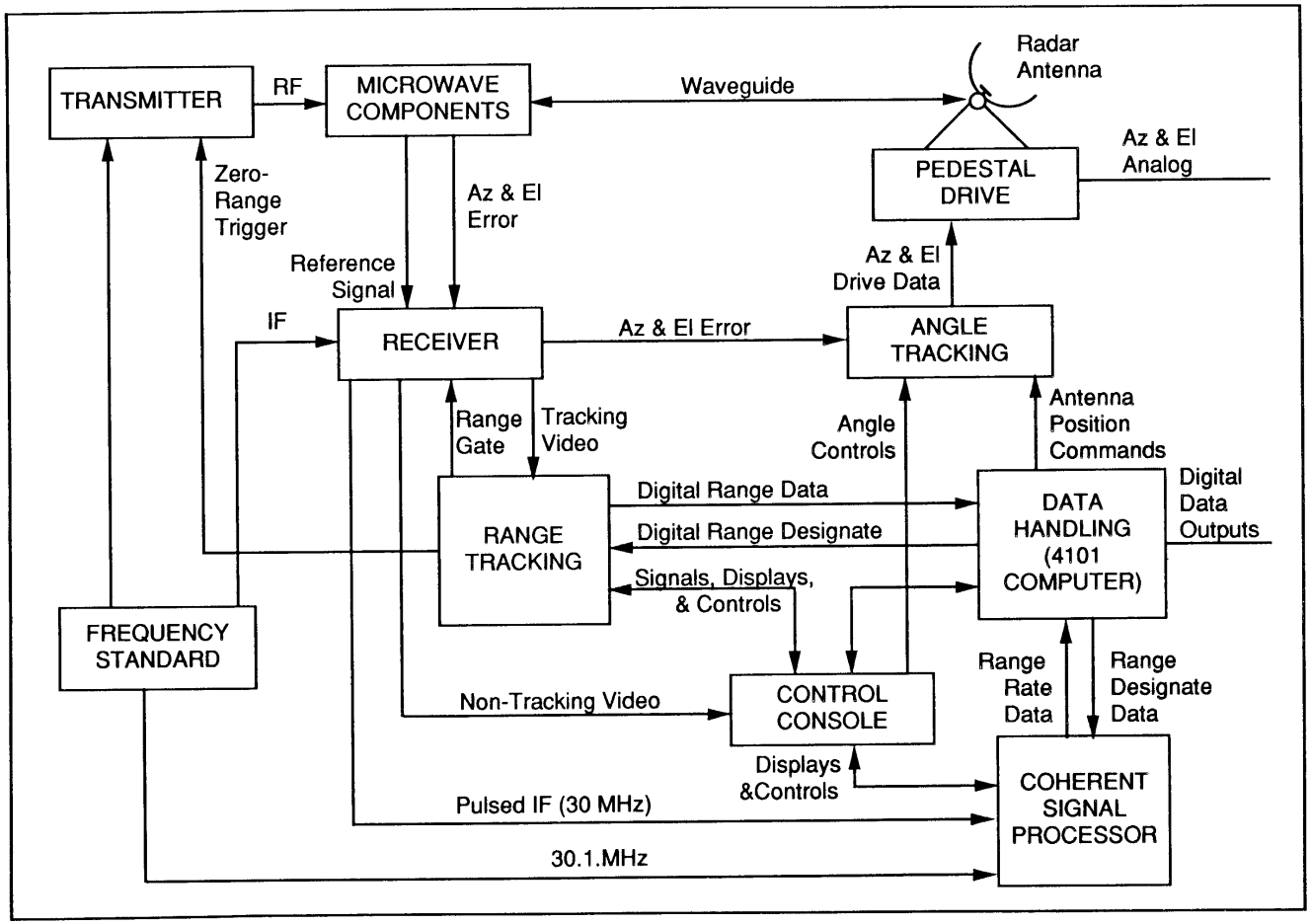

FIGURE 7. TYPICAL RADAR SYSTEM BLOCK DIAGRAM

(8) Radar Data Acquisition and Display Systems -There are three systems at WFF for radar data acquisition and display. They are the Radar Tracking System Target Acquisition and Display System (RATSTADS), the Space Vehicle Radar Target Acquisition System (STAR) and the Radar Data Graphics Display System (RDGDS). Each performs some of the following functions:

- Provide the means of remotely displaying the position of the radar target
- Allow all radars to slave their antennas to whichever radar has the target
- Ability to slave the command/destruct and telemetry antennas to the target
- Ability to slave WFF radars to a target acquired by radars not at WFF (e.g., KSC radars).

Five radars at WFF: two on Wallops Island, two on Wallops Mainland and one at the WFF airport on the Main Base, support these functions.[6]

b. Optic Systems - Wallops' photographic capabilities can provide complete documentation of any given rocket launch sequence, including medium-and high-speed tracking coverage of the vehicle flight, sequential coverage of the vehicle lift-off, intermittent and close-up studies of vehicle motor operation, documentary coverage of the vehicle assembly and still photographs of the vehicle in the horizontal and elevated positions on the launcher.

The flight of the vehicle is photographed by cameras on short range optical trackers (SOT) and intermediate focal length trackers (IFLOT). There are 2 fixed SOT's, 1 mobile SOT, 1 fixed IFLOT and 5 mobile IFLOT's. The fixed SOT's and IFLOT are housed in astrodomes on top of 25-foot towers. Eachtracking station is equipped with a voice communication system and 36-bit time code signals. When a SOT or IFLOT is installed in an astrodome, a servo drive system synchronizes the dome with the tracker. The IFLOT mounts are electro-hydraulically driven in azimuth and elevation and are operated by one man.[7]

c. Telemetry Systems - Wallops has ten independently controlled telemetry antenna systems. Seven are trailer-mounted transportable antennas and three are components of the following fixed systems: One Advanced Data Acquisition System (ADAS) and two Medium Gain Telemetry Acquisition Systems (MGTAS). All of these systems offer closed loop spatial tracking by sensing an RF signal radiated from the vehicle.

Where experiments employ multiple RF carriers, selection of a carrier for tracking purposes is a User's option, since it does not impinge on the reception of telemetry data. The fixed receiver system offers the User a high degree of flexibility and redundancy. Each of two identical systems contains six receivers with plug-in RF heads to cover the appropriate frequency band. NASA offers several transportable telemetry systems designed to provide temporary coverage at locations beyond that served by fixed facilities at Wallops.[9] **Figure 8**[9] shows a typical telemetry system block diagram.

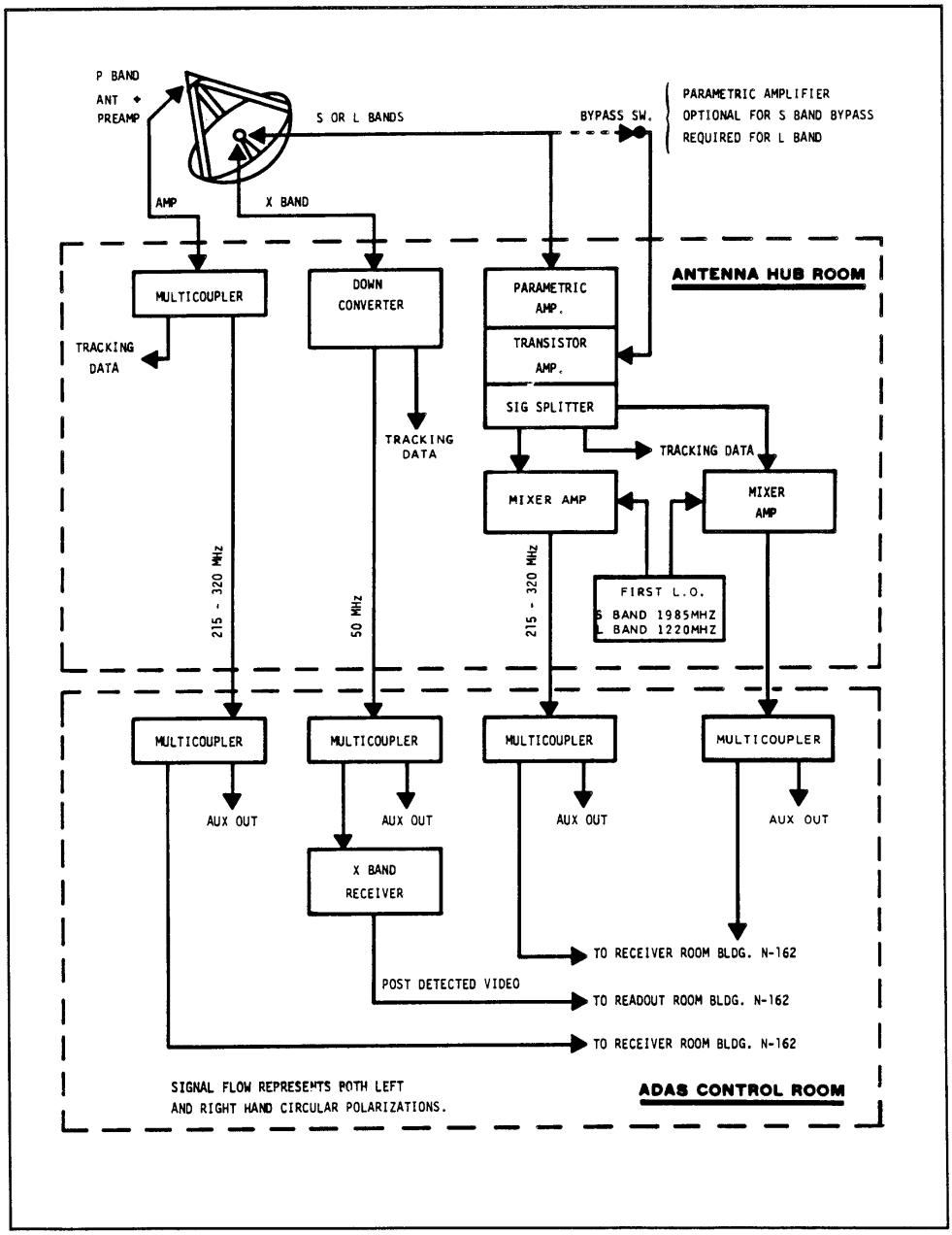

FIGURE 8. TYPICAL TELEMETRY SYSTEM BLOCK DIAGRAM

d. Communications Systems$_{10}$ - The communications systems outlined in paragraph **A.3.b.(4)** are located at Wallops Island, Wallops Mainland and Wallops Main Base, at remote stations and mounted in vans for downrange and shipboard use. RF support services include spectrum management, frequency monitoring and interference control, search, recovery and homing systems and meteorological information systems.

The Communications Receiver Facility is located on the Main Base in the Telecommunication Building, which houses the receivers, recorders, patching panels, command/destruct monitors and recorders and the supporting ancillary equipment.

The receiving antennas are mounted on towers and poles in the immediate area. World-wide reception is possible. The Frequency Monitoring and Interference Control facilities are collocated with the Communications Receiver Facility.

The Communications Transmitter Building is located on the Mainland and the transmitting antennas are mounted on top of the building and on towers and poles in the immediate area. An alternating current power generator for the redundant command/destruct and communications system is located in an adjacent building at this facility. World-wide transmission is possible.

The mobile facilities are defined as those mobile systems housed in vans which can be moved from place to place on the station, moved downrange or placed aboard ship.

These systems include the Mobile Command/Destruct System and the Mobile Closed-Circuit Television System.

e. Command/Destruct System$_{10}$ - The Command/Destruct Systems at Wallops provide ground control of certain rocket and payload functions for flight safety and/or other command purposes. The Range User can use these systems to command payload functions as necessary, within range limitations.

(1) Ground Transmitters and Antennas

(a) Fixed Command/Destruct System - Each permanent system consists of two Radio Transmitting Sets with Quad-helix antennas. Each transmitter has a minimum RF power output of 1000 watts in the frequency range of 406.0 to 549.0 MHz. The RF carrier is frequency modulated by certain pre-selected tones that correspond to particular functions that are to be performed on the rocket or payload. The carrier frequency is normally set at 412 MHz; however, other frequencies can be used if required for special cases, i.e., 416.5 MHz when being used in support of a launch from the Eastern Test Range, 447 MHz for vehicle commands and 425 MHz for drone vehicles. In addition, IRIG tone 7 is sometimes used to replace tone 5 when WSMR receivers are being used. The transmitted signals are monitored and recorded at the Transmitter Building by a receiver-audio decoder combination. There are three Command/Destruct Systems available at Wallops, two fixed systems located on the Mainland and a Mobile System. These systems work in conjunction with the Bermuda Command/Destruct system when

required.

The fixed system consists of two subsystems connected in a fail-over arrangement. If the primary subsystem fails, or if the RF power output falls below a predetermined level, fail-over is automatically initiated. The redundant subsystem then assumes control of the Command/Destruct function.

(b) Primary Command/Destruct Subsystem - The Primary Command/Destruct Subsystem consists of an ALEPH CTS-100 Transmitting Set, an ANTLAB Quad-helix antenna and the necessary control circuits.

The transmitter modulation can by controlled locally, or by remote control from the Range Control Center. The transmitter and antenna pedestal operate from commercial AC power. The primary antenna is slaved, by means of the radar data acquisition bus, to a radar selected to provide the most accurate position information on the rocket/payload being tracked.

The RSO can remotely control certain functions of the rocket or payload such as the arming and destruction of a rocket, or specific rocket or payload mission commands that may be required. System status and verification indications are provided to the RSO. **Figure 9**$_{10}$ shows a typical block diagram of a command system.

(c) Redundant Command/Destruct System - The Redundant Command/Destruct Subsystem (identical to the primary) is powered by a local generator so that, in case of a failure of commercial power during a mission, control will still be maintained over the rocket/payload. The Quad-helix antenna used with this subsystem is positioned manually using predetermined angle versus time information.

(d) Mobile Command/Destruct System - The Mobile Command/Destruct System consists of two Collins AN/FRW-2A Radio Transmitting Sets and associated equipment mounted in a mobile van. Each transmitter has a minimum RF power output of 500 watts in the frequency range of 406.0 to 549.0 MHz. The equipment is connected in a fail-over arrangement and can be used downrange for prime operation or as a backup system in support of the Wallops Mainland system. A small, manually pointed, crossed-dipole antenna is used as a spare. Transmitter modulation can be controlled locally.

(e) Digital Range Safety Command Set - The Digital Range Safety Command Set was designed to operate in conjunction with the Eastern Test Range for Command/Destruct control of launches by Kennedy Space Center during Shuttle operations.

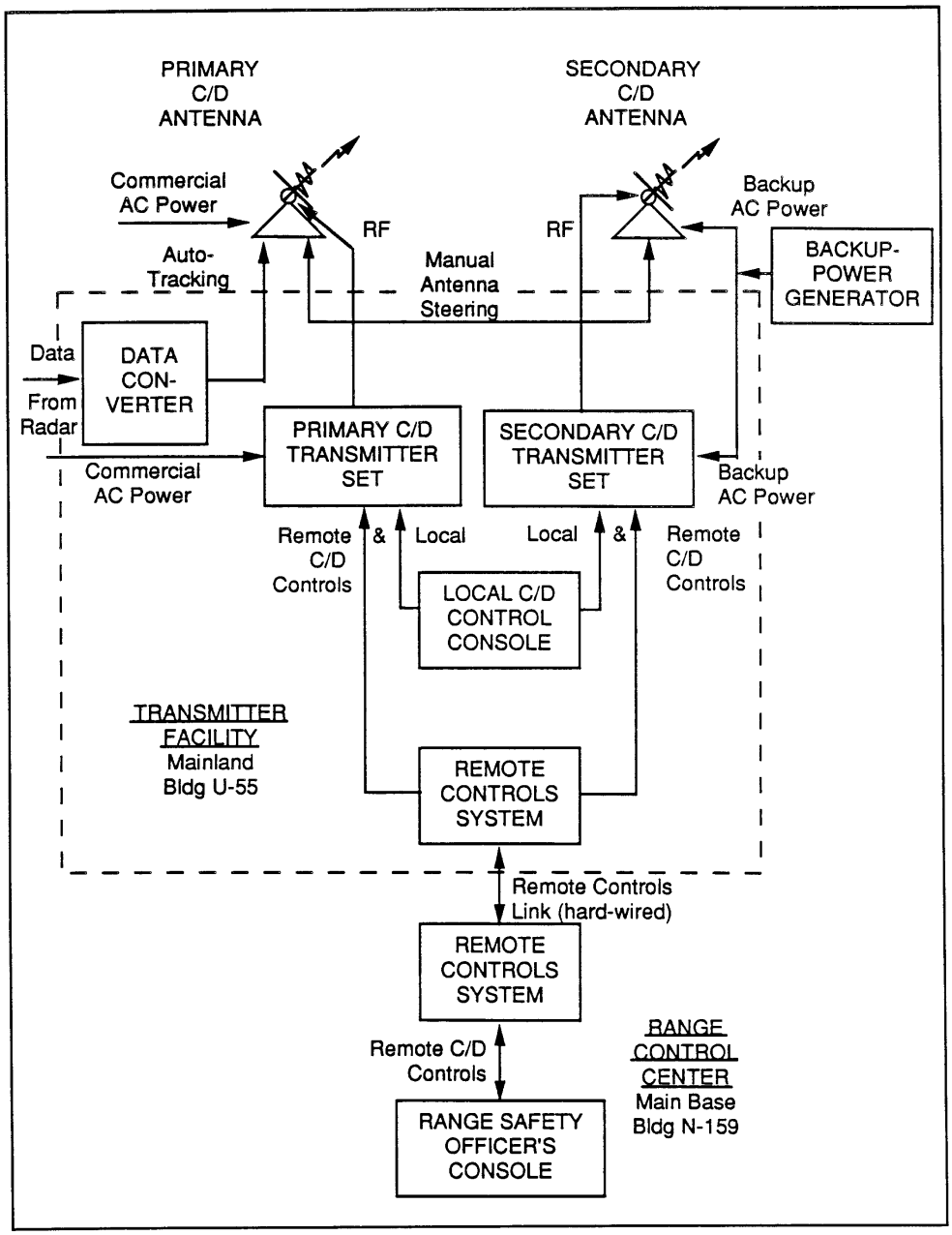

FIGURE 9. TYPICAL COMMAND SYSTEM BLOCK DIAGRAM

(2) Launch Vehicle Flight Termination System (FTS)

(a) Design - If it is determined by the WFF Range Safety personnel that a Flight Termination System is required, a system must be employed whereby thrust may be terminated, stage ignition prevented or delayed, or other means employed to insure that the impact and overflight criteria are not exceeded. A preliminary design of a vehicle FTS must be submitted to the Ground and Flight Safety Section by the Range User for analysis and approval.

For the majority of rocket vehicles flown from WFF that require flight termination systems, WFF Range Safety furnishes A.R.F. 9B, 4-channel command receivers. If the Range User elects to provide his own receivers, they must meet the minimum command receiver/decoder specifications as described in the WFF Range Safety Handbook.

(b) Operation - The standard flight termination scheme is to frequency modulate the carrier with three audio tones to effect "ARM" (fuel cut-off/shutdown for liquid propellant engines) and "DESTRUCT". The audio tones are standard at all ranges and were established by the Inter Range Instrumentation Group (IRIG). Normally, tones 1 and 5 are transmitted as the "ARM" command. This cuts off thrust to a liquid fueled booster and conditions the airborne receiver logic to receive and act upon a "DESTRUCT" command. "DESTRUCT" will not be acted upon unless preceded by "ARM". Tone 1 is kept on, tone 5 removed and tone 2 added to effect "DESTRUCT".[3]